Detecting life in extraterrestrial samples: planetary protection investigations

SIO, Feb 15-17, 2012

Summary of Workshop Plans

Life detection investigations will be considered within the framework of what it means to 'detect life', including appropriate application of the Null Hypothesis and other formalisms useful in the development of specific criteria for making a credible claim of life detection. Discussion is encouraged of the potential for measurements that address broader scientific questions to be used also for planetary protection purposes to meet criteria for release of samples from containment, which could minimize use of scarce samples and duplication of effort.

Workshop Objectives: (*bullet list*)

- Evaluate current and possible scientific investigations that could identify signs of viable, extant life in samples returned from Mars.
- Assess the state-of-the-art of available technologies and identify areas that require future work.
- Discuss efficient phasing of planetary protection measurements in the context of proposed scientific analyses (e.g., E2E SAG study).
- Identify needed improvements in sample preparation, detection technologies, and controls/blanks that would increase confidence in the results.

Goal for Workshop Subgroups:

To identify sample processing strategies, analytical technologies, and decision making procedures for life detection in samples returned from (1) subsurface/deep ocean, (2) glaciers/permafrost, and (3) hyperarid/saline environments.

General Thematic Questions for the Workshop:

What does a definitive life detection "event" look like?

How many lines of evidence does this include?

Which lines of evidence are the most compelling?

Summary of Workshop Questions:

Process/Measurements

- What should a life-detection protocol look like?
- Are there commonalities to life that could simplify the detection process?
- What are different kinds of measurements good for?
- What measurements make sense and when?
- How shall the sample be analyzed and in what order (progression from non-destructive to destructive)?
- How shall the life detection protocol/s be tested, and on what kind of sample?
- What type of macro-scale measurements should be made?
    - Non-Destructive/Tomography Types
    - Surface Analysis/Imaging Techniques
    - Others? (solvent-based, macromolecules…)
- What type of micro-scale measurements should be made?
    - Localized Probe-Type/Destructive Approaches
    - Others? (sample processing, etc.)

Molecular

- Should the protocol include measurements for proteins, carbohydrates, nucleic acids, and/or lipids?
- Should the protocol include measurements for secondary metabolites (or micromolecules)?
- What type of measurements does this include?

Metabolic

- What type of metabolic processes should the protocol address for detection?
- What type of catalytic processes could the protocol address for detection?

Morphology

- What type of geo. and/or bio. structures should the protocol address for detection?
- What type of measurements does this include?

Future Directions/Concerns

- What's missing from the protocols/workshop?
- What are the future directions for (A) sample handling, (B) analytical technology, (C) other?

Summary of Workshop Topics:

- 'Nondestructive' Technologies & Approaches -- i.e., analyses done for multiple purposes

- Morphological Evaluation (growth forms, habitat structures, bodies, etc.?)
  - Computer Tomography (what information can be gained: internal structure? compositional assessment? I.e., is elemental analysis possible using CT X-rays)
  - Microscopy, light/fluorescence and electron; (incl. phase-contrast/birefringence/other?)

- Compositional Evaluation (indications of biology/biological fractionation?)
  - LD/GC Mass Spec. (also used during laser-cutting preparation of thin sections?)
  - XRD/mineralogy
  - Raman & other spectroscopy (also on intact sample cores to inform initial structural assessment?)
  - Isotopic & Elemental analysis of small areas of interest (microprobe, nanoSIMS, other?)
  - Chemical/organics analyses?

- 'Destructive' Technologies & Approaches
  - Toxicity testing; chemical composition/reactivity
  - Microcosm/culture tests (incl. calorimetry/metabolic activity assessments?)
  - Chip-based affinity approaches (nucleic acid/protein/polysaccharide/other)
  - Microscopy, SEM & light (as used to identify 'Cambrian contamination' in Precambrian life studies?)

- Theoretical considerations for life detection
  - Thermodynamic disequilibria; biological fractionation (isotopic fractionation, subsets of organic molecules, building blocks, chirality, ...) etc.

- Sample Preparation Technique Optimization
  - Minimize waste; ensure best use of grinding fines and other sample preparation byproducts
  - E.g., can laser cutting be adapted for use by vapor-phase analytical techniques?

- Appropriate Blanks and Controls
  - in-flight and round-trip contamination
  - sample acquisition and processing
  - other?

- ***Are there other relevant topics?***